# Final Paper on Integrated Multipurpose Water Resource Management: The Wardha-Penganga Project

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**ABSTRACT:**

Integrated multipurpose water resource management: The Wardha Penganga project helps to manage water in a smart and sustainable way. Integrated multipurpose water resource management is a method that combines different uses of water—such as irrigation for farming, hydroelectric power generation, and flood control—into a single project. One such potential project is the proposed dam on the Penganga Rivers and it is interlinking Wardha River in Maharashtra. This project is especially important for the Vidarbha region, which often faces water shortages and agricultural distress. By storing and distributing water efficiently, the dam could help farmers grow crops throughout the year, even during dry seasons. It could also generate clean electricity through hydropower. The research compares this proposed project with the Polavaram Multipurpose Project on the Godavari River, a major example of successful integrated water management in India. The research looks at things like rainfall, land, environment, and how people might be affected to see if the project would work well. Early results show that if planned properly, the project could help farmers in the Vidarbha region, provide electricity, and make water more secure. The paper also suggests a model for how to develop the region in a way that's good for both people and the environment.

**Keywords:** Integrated multipurpose, Irrigation, Hydroelectric power, Flood control, Polavaram Multipurpose Project, Vidarbha region, Maharashtra.

## 1. INTRODUCTION:

The Wardha-Penganga Multipurpose Project in Maharashtra is a significant initiative focused on water resource management, aiming to address crucial issues such as flood reduction, energy production, and agricultural growth. This project is designed to enhance water availability in the region, improve irrigation infrastructure, and support renewable energy generation, ultimately fostering economic and social development. The inspiration for this project comes from similar large-scale initiatives, such as the Polavaram Multipurpose Project in Andhra Pradesh, which has successfully tackled regional water shortages and contributed to sustainable irrigation and hydropower generation.

The Wardha and Penganga Rivers, as important tributaries of the Godavari River, offer great potential for supporting extensive irrigation and hydropower projects. By harnessing the water resources of these rivers, this project aims to provide efficient water distribution to Vidarbha's drought-prone areas, ensuring year-round irrigation for agriculture and improving overall

Fig 1: Integrated Multipurpose Project View

productivity. The project plan includes the construction of a large dam, a network of interconnected canals, and reservoirs to optimize water storage and distribution. Additionally, integrating hydropower generation into the project design guarantees a sustainable and renewable energy source to meet the growing demands of local communities, industries, and urban settlements.

### 1.1. Background

Due to its agrarian economy, India is highly dependent on its water resources for industry, agriculture, electricity generation, and drinking water. Integrated multifunctional river projects are now essential for managing and using limited water resources sustainably due to unequal rainfall distribution and rising water demands.

### 1.2. Need for Multipurpose River Projects

The goal of multipurpose projects is to accomplish multiple tasks, such as flood control, drinking water supply, irrigation, hydropower production, and environmental preservation. A notable example of the effectiveness of integrated methods to water resource development is the Polavaram Project in Andhra Pradesh.

### 1.3. About Wardha and Penganga Rivers

Madhya Pradesh is the starting point of the Wardha River, which then runs into Maharashtra before joining the Penganga River, which rises from the Ajanta mountains. These rivers work together to form the Pranhita sub-basin, which is a key tributary of the Godavari River system. Since the basin includes a number of districts that are vulnerable to drought, such as Wardha and Yavatmal, water management is a top concern for the area.

### 1.4. Motivation of the Study

Large portions of the Wardha-Penganga basin are still underutilized because of inefficient infrastructure for water storage, distribution, and management, even though the top regions receive a lot of rainfall. In order to unlock the irrigation, hydropower, and socioeconomic potential of the Wardha-Penganga river system, this article suggests a conceptual multipurpose project that draws inspiration from Polavaram's success.

### 1.5. Types of Dam:

**Classification based on materials of construction:**

**1] Earth fill dams: -**

An earth fill dam is a kind of embankment dam that is mostly made of compacted dirt and frequently has a clay core to stop water seepage. Often employed for flood control, irrigation, and water storage, these dams withstand water pressure by virtue of their weight and sloping design.


Fig 2: Earth fill dam

**2] Rock fill dams: -**

A rock fill dam is a type of embankment dam constructed primarily with loose rocks and boulders, with an impermeable core or upstream facing to prevent water seepage. These dams rely on the weight of the rock materials to provide stability and withstand water pressure. The impermeable barrier is typically made of clay, asphalt, or concrete to minimize leakage.

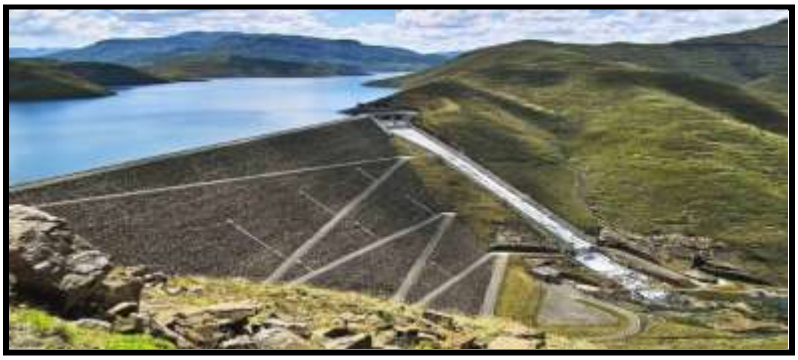

Fig 3: Rock fill dam

**3] Concrete dams: -**

A substantial structure composed mostly of concrete, a concrete dam is intended to restrict or manage the flow of water in reservoirs and rivers. These dams can be constructed in a variety of configurations, such as gravity dams, arch dams, and buttress dams, depending on the site conditions. They rely on their weight and structural strength to withstand water pressure. Concrete dams are very resilient, can resist severe weather, and need little upkeep over an extended length of time. Water supply, irrigation, flood control, and hydroelectric power generation are among their frequent uses.

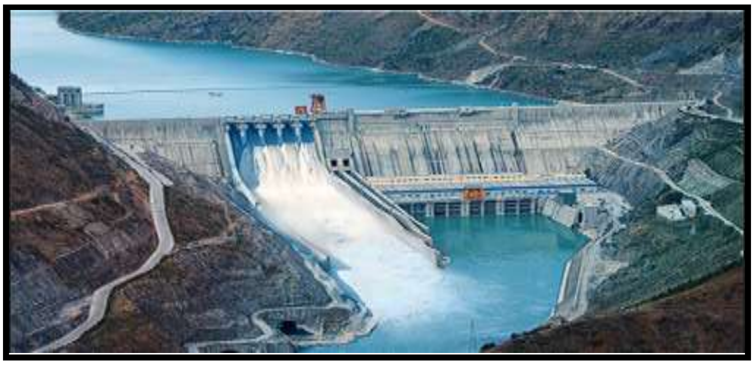

Fig 4: Concrete dam

**4] Masonary dams: -**

Masonry dams are made of stone or brick masonry that is joined together with mortar. Similar in operation to gravity dams, these dams use their weight to withstand water pressure. Solid masonry dams, which are constructed entirely of stone or brick, and composite masonry dams, which combine a masonry structure with a concrete core or face, are the two primary types of masonry dams.

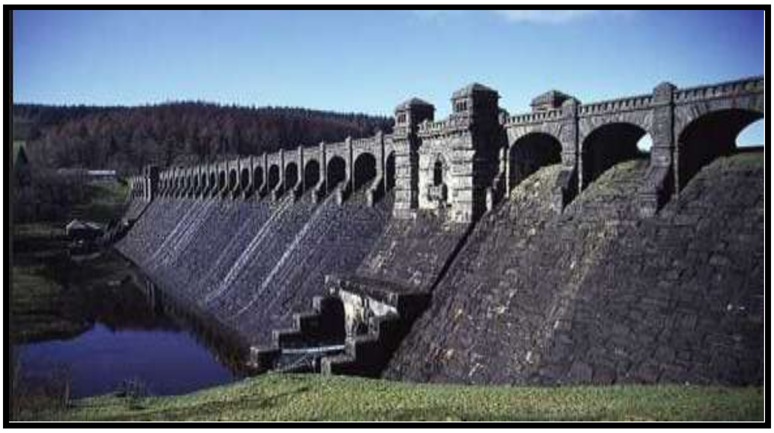

Fig 5: Masonry dam

**Classification based on types of construction:**

**1] Gravity dams: -**

One kind of dam that uses its own weight to withstand water pressure and keep stability is called a gravity dam. These dams, which are mainly made of concrete or masonry, are broad at the base and slope or face upstream to offset the force of water rushing against them. Gravity dams' main benefit is their great strength and longevity, which makes them appropriate for large-scale water storage, flood control, and hydroelectric power production.

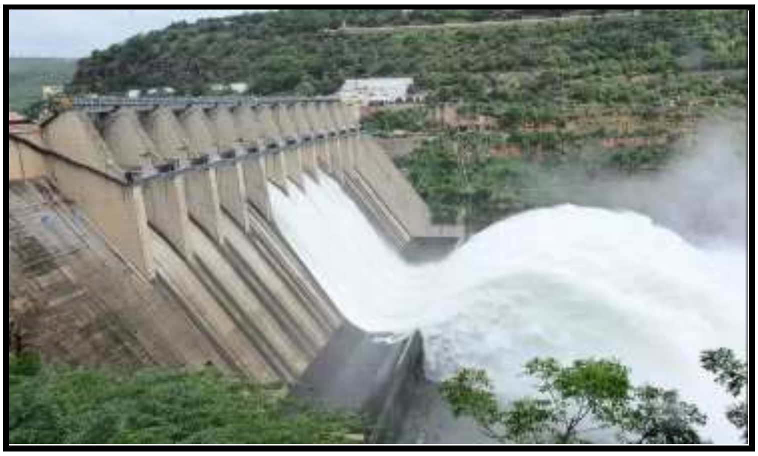

Fig 6: Gravity dam

**2] Buttress dams: -**

A buttress dam is a type of reinforced concrete dam that resists water pressure while using less material during construction by using a number of supports, or buttresses, on the downstream side. These dams can be flat slab, multi-arch, or large head buttress designs, all of which are tailored to the particular site conditions. Because the water load is transferred to the foundation by the buttresses, the structure is lighter than conventional gravity dams and appropriate for weaker foundations.

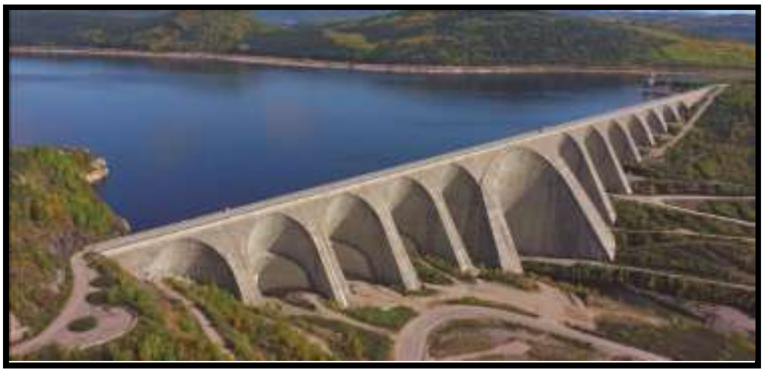

Fig 7: Buttress dam

**3] Arch dams: -**

A concrete dam that curves to transfer water pressure to the surrounding rock walls of a small valley or canyon is called an arch dam. Arch dams employ their curved design to distribute pressure efficiently, making them smaller and using less material than gravity dams, which rely on their weight to resist water force.

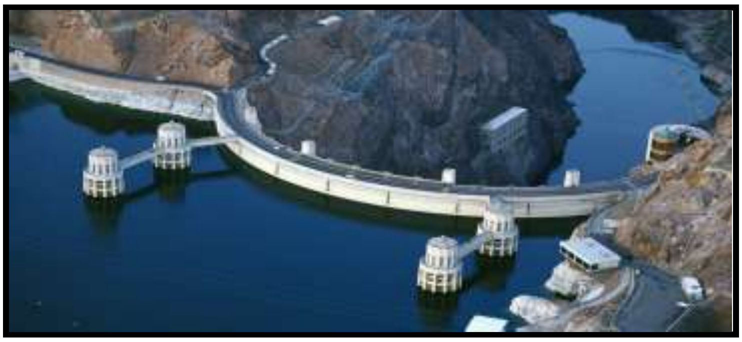

Fig 8: Arch dam

## 3. METHODOLOGY:

### 3.1. Survey

The Wardha- Pennganga Project is a significant irrigation initiative in Maharashtra, India, covering Amaravati, Wardha and Yavatmal districts. The Wardha- Penganga project appears to involve various development initiatives, including irrigation, water resources, and infrastructure projects. For the data collection various surveys are done are as follows:

**3.1.1] Catchment Area Survey:**A catchment area is the total land area from which rainwater and runoff collect and drain into a particular river, lake, or reservoir.

**1) Wardha River catchment area: -**

Catchment area of Wardh River is 46000 sq.km is given in Maharashtra River linking project report.

| Sub Basin Name | Approx. Area (sq.km) |
|---|---|
| Upper Wardha (near origin) | 7,000-9,000 |
| Middle Wardha (Yavatmal, Wardha) | 17,000-21,000 |
| Lower Wardha (before Penganga) | 12,000-16,000 |
| **Total** | **~46,000 sq.km** |

Table 1: Catchment Area of Wardha River

**2) Penganga River catchment area: -**

Catchment area of Penganga River is 16000 sq.km is given in Maharashtra River linking project report.

| Sub Basin Name | Approx. Area (sq.km) |
|---|---|
| Upper Penganga | 3,000 - 4,000 |
| Middle Penganga | 6,000 – 7,000 |
| Lower Penganga | 4,000 – 5,000 |
| **Total** | **~16,000 sq.km** |

Table 2: Catchment Area of Penganga River

Total catchment area of Wardha and Penganga River = 46,000+16,000

= **62,000 sq.km.**

The Catchment area of Wardha Penganga Project is ~62,000 sq.km.

**3.1.2] Rainfall Survey:**

Rainfall survey data of Wardha and Penganga River basin are as following.

| District / Region | River Basin | Avg. Rainfall (mm/year) |
|---|---|---|
| Amravati (Upper Wardha) | Wardha | 900 – 1,100 mm |
| Wardha (Mid–Lower) | Wardha | 850 – 1,000 mm |
| Yavatmal (Common zone) | Both Basins | 1,000 – 1,150 mm |
| Chandrapur (Lower Wardha) | Wardha | 1,100 – 1,250 mm |
| Hingoli (Upper Penganga) | Penganga | 800 – 1,000 mm |
| Nanded (Mid Penganga) | Penganga | 900 – 1,100 mm |
| Adilabad (Lower Penganga) | Penganga | 1,000 – 1,200 mm |

Table 3: Rainfall Survey

Average Rainfall Wardha River and Penganga River (Basin) are follows.

Weighted Avg Rainfall= ∑(Area×Rainfall)/∑Area

The Average Rainfall in Wardha River Basin = 46,000*1,050/46,000

= 1,050 mm/year

The Average Rainfall in Wardha River Basin is ~1,050 mm/year.

The Average Rainfall in Penganga River Basin = 16,000*1,000/16,000

= 1,000 mm/year

The Average Rainfall in Penganga River Basin is ~1,000 mm/year.

**Applications of Rainfall Survey:**

- **Agricultural Planning:** Informing crop selection, irrigation systems, and water management strategies.
- **Water Resource Management:** Helping to manage water supplies, predict floods, and mitigate droughts.
- **Urban Planning:** Informing urban design, drainage systems, and flood risk management.
- **Climate Research:** Contributing to the understanding of climate patterns, trends, and variability.

**Benefits of Rainfall Survey:**

- **Improved Water Management:** Enabling more effective management of water resources.
- **Enhance Agricultural Productivity:** Supporting informed decision – making in agriculture.
- **Reduced Flood Risk:** Helping to mitigate the impact of flooding on communities and infrastructures**.**

### 3.1.3] Storage Capacity Survey:

Storage capacity refers to the total volume of water that a reservoir, dam, tank, or any water-retaining structure can hold or store. It is a critical concept in water resource management, especially in irrigation, flood control, drinking water supply, and hydropower.

**1)Wardha River Storage capacity: -**

From the Irrigation department the Wardha River Storage capacity data is collected.

| Project Name | Type | Location | Live Storage Capacity (MCM) |
|---|---|---|---|
| **Upper Wardha Dam** | Major Project | Amravati District | ~614 MCM |
| **Lower Wardha Project** | Major Project | Wardha District | ~305 MCM |
| **Bembla Project** | Major Tributary (Bembla) | Yavatmal District | ~372 MCM |
| **Arunawati Dam** | Medium Project | Yavatmal District | ~100 MCM |
| **Ner Dam** | Medium Project | Yavatmal District | ~60 MCM |

Table 3: Wardha River Storage capacity

The Total Storage capacity = 614+305+372+100+60

= **1,451 MCM** (Million Cubic Meters)

The Total Storage capacity of Wardha River is 1.451 BCM (Billion Cubic Meters)

**2) Penganga River Storage capacity: -**

From the Irrigation department the Penganga River Storage capacity data is collected.

| Project Name | Type | Location | Live Storage Capacity (MCM) |
|---|---|---|---|
| **Isapur Dam** | Major Project | Hingoli District (MH) | ~960 MCM |

| | | | |
|---|---|---|---|
| **Lower Penganga Project** | Major Project | Yavatmal District (MH) | ~552 MCM |
| **Upper Penganga (Isapur feeder)** | Medium Project | Hingoli/Nanded Region | ~120 MCM |
| **Pus Dam** | Medium Project | Pusad, Yavatmal (MH) | ~90 MCM |
| **Sina Kolegaon Project** | Medium Project | Nanded District (MH) | ~70 MCM |
| **Lendi Project** | Medium Project | Nanded District (MH) | ~50 MCM |
| **Misc. Minor Projects** | Minor Tanks, Weirs | Throughout basin | ~100 MCM |

Table 4: Penganga River Storage capacity

The Total Storage capacity = 960+552+120+90+70+50+100

= **1,942 MCM** (Million Cubic Meters)

The Total Storage capacity of Wardha River is 1.942 BCM (Billion Cubic Meters)

The Total storage capacity of Wardha and Penganga River = 1.451+ 1.942

= **3.393 BMC**

The Total storage capacity of Wardha and Penganga River project is 3.393 BMC

**3.1.4] Irrigation Potential:**

Total Water storage of Wardha and Penganga River is 3,393 MCM.

Assume , 75% of efficiency ( Which is typically used for irrigation)

| **Crop Type** | **Water Requirement (MCM/ha)** | **Estimated Irrigation Potential** |
|---|---|---|
| Rice | 1.2 MCM/ha | ~2.19 million hectares |
| Wheat | 0.8 MCM/ha | ~3.28 million hectares |
| Cotton | 0.7 MCM/ha | ~3.75 million hectares |

Table 5: Irrigation Potential

Total Irrigation Potential for rice = 3,393 MCM*0.75/1.2 MCM/ha

= 2,120,625 ha

= 2.12 million hectares

Total Irrigation Potential for Wheat = 3,393 MCM*0.75/0.8 MCM/ha

= 3,180,937 ha

= 3.18 million hectares

Total Irrigation Potential for Cotton = 3,393 MCM*0.75/0.7MCM/ha

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 04 | April - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

= 3,635,357 ha

= 3.63 million hectares

Average of Irrigation Potential = 2.12 + 3.18 + 3.63 / 3

= **2.97 million hectares**

The Irrigation Potential for Wardha Penganga river project is ~2.97 million hectares.

**3.1.5] Design of Dam:**

**Spillway:**

- Type: Ogee
- Length: 405 m (from RD 870 m to RD 1245 m)
- Crest Level: 253.50 m
- Design Flood: 25160.38 cumec
- Gates: 25 radial gates of size 12 m x 8 m

**Dam Dimensions (Approximate):**

- Total length of dam (including spillway): 1998 m
- Maximum height of the earth dam portion: 35.63 m
- Freeboard above FRL: 4.5 m
- Freeboard above Maximum Water Level (MWL): 2.5 m
- Discharge: 100 cubic meter/sec

**Proposed location for dam:**

Takali, Takali is situated in Amaravati district, Maharashtra.

Takali pin code is 444728 with 21.17845 latitude and 77.27185 longitude.

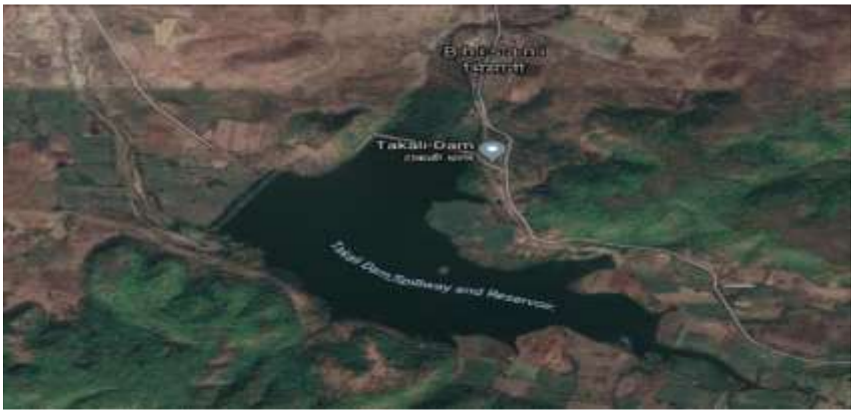


**Fig 9: Takli Dam Location**

**3.1.6] Hydropower Potential Survey:**

To estimate hydropower generation, we use above design data.

Calculation of hydropower generation calculated by following formula:

Power (P) = $\rho \times g \times Q \times H \times \eta$

Where,

-Density of water: 1000 kg/cu.m

-Acceleration due to gravity: 9.81 m/sq.s

- Head (H): 35.63 meters

- Flow rate (Q): 100 $m^3/s$

- Efficiency ($\eta$): 0.75 (75%)

Using the formula:

$P = 1000\ kg/m^3 \times 9.81\ m/s^2 \times 100\ m^3/s \times 35.63\ m \times 0.75$

$P \approx 26.215$ MW

To calculate the annual energy production:

AEP = P × 8760 × Capacity Factor

Assuming a capacity factor of 0.5:

AEP ≈ 26.215 MW × 8760 hours/year × 0.5

AEP ≈ 114.82 GWh/year

The Hydropower Potential for Wardha Penganga river project is ≈ 114.82 GWh/year.

**4. RESULTS:**

Surveys are crucial for the Wardha-Penganga project because they determine feasibility of project, provide accurate data for designing infrastructure, detect potential environmental and social risks, help mitigate negative impacts and promote sustainable development, facilitate efficient allocation of resources and budgeting, and identify potential hazards and ensure the safety of workers and local communities. By conducting surveys, the project can be planned and executed effectively, minimizing risks and ensuring successful outcomes. For this project we have done different types of surveys are as follows:

1) Catchment Area Survey.
2) Rainfall Survey.
3) Storage Capacity Survey.
4) Irrigation Potential Survey.
5) Hydropower Potential Survey.

From the above surveys we get following results.

- The Catchment area of Wardha Penganga Project is ~62,000 sq.km
- The Average Rainfall in Wardha River Basin is ~1,050 mm/year.
- The Average Rainfall in Penganga River Basin is ~1,000 mm/year.
- The Total storage capacity of Wardha and Penganga River project is 3.393 BMC.
- The Irrigation Potential for Wardha Penganga river project is ~2.97 million hectares.
- The Hydropower Potential for Wardha Penganga river project is ≈ 114.82 GWh/year.

**5. FUTURE SCOPE:**

- Using sprinkler and drip irrigation, among other contemporary irrigation methods.
- In order to provide water throughout the year, canal networks and reservoirs should be expanded.
- Smart irrigation systems and digital water monitoring are being implemented.
- Dam operations are optimized to generate as much electricity as possible.
- The use of smart grid technology to distribute energy efficiently.
- Investigation of hybrid energy options that combine wind, solar, and hydropower.
- Boosting conservation initiatives for watersheds to stop soil erosion.
- Support for projects aimed at groundwater recharging and rainwater collection.policy creation that is climate resilient in order to address the effects of climate change.

**6. CONCLUSION:**

The Wardha-Penganga Project is a historic endeavor in integrated water resource management that seeks to raise agricultural output, provide renewable energy, and enhance local populations' quality of life. The goal of this project is to provide ease, efficiency, and resilience by streamlining the delivery of energy and water across multiple sectors. The project promotes sustainable development by tackling local issues like irregular irrigation, energy scarcity, and climate variability. Its careful design, which places a strong emphasis on connectivity—between towns, between industries, and between rivers—reflects the value of operational infrastructure in both academic and practical contexts. The Wardha-Penganga Project could serve as a template for other multifunctional river projects in India with inclusive governance and technology integration.

We believe that the successful completion of this project will bring significant advantages to the Vidharbha region in Maharashtra and we make a proposed model for this project.

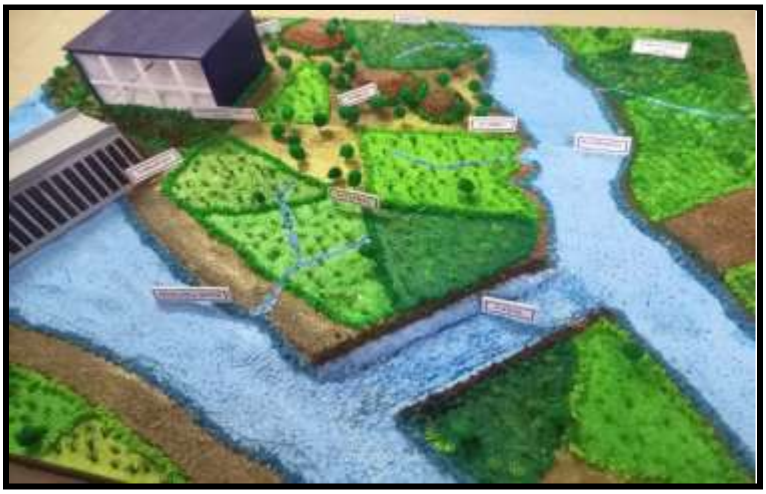

**Fig 10: Proposed Model**

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